Polarity of GaN Thin Film Grown on Si-Face SiC Probed by X-ray Standing Wave

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Beamline(s): **X15A**

Introduction: Reliable determination of the polarity of GaN films grown by different techniques on different substrates presents a challenging experimental problem important for understanding the chemical and physical properties of these films and GaN-based electronic devices [1]. In [2] the XSW method was applied to study thin GaN film grown by plasma-induced MBE on sapphire. Opposite to the Ga-polarity found for MOCVD grown films, the N-polarity was found for these MBE grown films. In the present work we applied the XSW method to determine polarity of a GaN epitaxial film grown by hydride vapor phase epitaxy on the Si-face SiC.

Methods and Materials: The GaN epitaxial layer was grown by the hydride vapor phase epitaxy (HVPE) directly on the (0001) Si face of commercial 6H-SiC on-axis 2-inch diameter wafer without any buffer layer [3]. The thickness of the GaN layer was 300 nm.

The experiments were performed at the X15A beamline. The x-ray standing wave was generated inside the film using Bragg diffraction from the film. The angular dependence of the Ga-K fluorescence was measured while scanning the crystal through the GaN (0002) diffraction peak.

Results To fit the experimental XSW data, first, the theoretical X-ray curve was convoluted with the Gauss function to take account for the mosaic spread. The same Gaussian function was then used for the convolution of the calculated fluorescence yield. Then, the Ga-K XSW fluorescence yield calculated for the Ga- and N-polar GaN film was fitted to the experimental data by using a static Debye-Waller factor as the only fitting parameter (Fig.1). For all experimental data the XSW analysis gives significantly lower χ^2-values for the Ga-face film (Fig.2). Thus, our results unambiguously shows that a Ga-face GaN film grows on a Si-face SiC substrate, i.e. the film grows in the [0001] direction with the upper part of the atomic double layer occupied by Ga atoms.

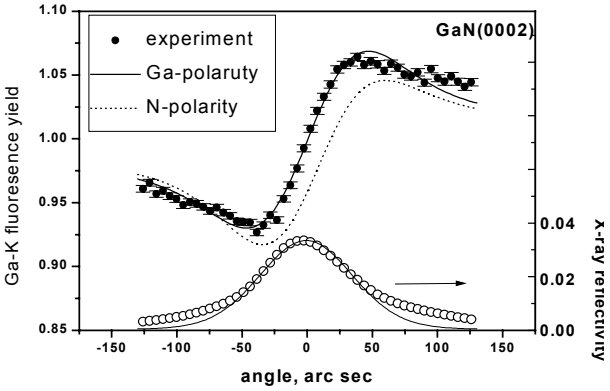

Figure 1. One of the experimental XSW data sets measured from the 300 nm thick GaN film. The experimental X-ray reflectivity curve (bottom) is shown as open circles, the solid line is the convolution of the theoretical X-ray rocking curve with the Gaussian function with σ=31.5 arc sec. The experimental Ga-K fluorescence yield is shown at the top as solid circles; the solid line is the best fit for the Ga-face film yielding the static Debye-Waller factor e^{-W}=0.71. The theoretical curve for the N-face is shown as a dotted line for comparison.

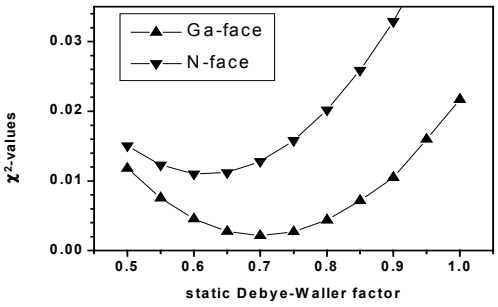

Figure 2. The χ^2 values as a function of the static Debye-Waller factor used as the only fitting parameter for the Ga-face (up triangles) and N-face GaN film (down triangles). The Ga-face model gives five times lower χ^2 values than the N-face model.

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References:

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